

Use of GIS Data for Allocating Aircraft, Commercial Marine Vessel and Rail Emissions to the County Level

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Introduction

In developing a national emissions inventory, it is sometimes possible to estimate emissions at the national level, but very difficult to disaggregate these national estimates accurately to the county level. As an example, in the 1996 nonroad component of the National Toxics Inventory (NTI), several states identified counties that did not have railroad tracks, but were showing rail emissions in the inventory. This was because an appropriate surrogate for railroad activity was not readily available at that time, and population, which is not strongly correlated to rail activity, was used as a surrogate. Somewhat similar issues were noted for commercial marine vessels (CMV). In the 1996 NTI, all CMV emissions were allocated to the largest 150 ports based on the amount of cargo handled. This approach led to an overestimation of port emissions, as underway emissions could not be spatially allocated at that time to individual shipping lanes; therefore, these emissions were not removed from the port estimates. To allocate airport emissions, Landing and Take-Off (LTO) data for 600 airports were used in the 1996 inventory. This listing did not include many of the smaller municipal airports that primarily service general aviation and air taxis, such that emissions were over estimated for the identified airports.

In the 1999 National Emissions Inventory (NEI) criteria and hazardous air pollutant (HAP) emissions from aircraft, CMV and railroads were estimated in a coordinated fashion. These estimates were released by EPA in November 2001. The emission allocation methodologies were significantly improved through use of available GIS data sets from a variety sources including the Department of Transportation, the Army Corps of Engineers, and the Federal Aviation Administration (FAA). County level emissions for all of the above nonroad categories were estimated by overlaying county level maps onto the GIS data set and totaling emissions within each county polygon.

These GIS techniques were reasonably easy to implement for the 1999 emission inventories and plans are currently being considered for revising the 1990 and 1996 HAP and criteria inventories using these techniques.

Summary of Methods used in the current version of the 1996 NTI

Aircraft

The NTI includes large jet-powered aircraft, which are used by commercial air carriers. Smaller commuter aircraft which are referred to as air taxis are also included in this inventory. Air Taxis represent small jet-powered aircraft and piston driven aircraft. Aircraft associated with general aviation are also included, these are aircraft are typically powered by piston engines. Military

aircraft are not included in the NTI as accurate activity data or fleet characterization data are not readily available.

National aircraft-specific activity data were obtained from the FAA's *Airport Activity Statistics of Certified Route Air Carriers, 12 Months Ending December 31, 1996*. To estimate emissions of criteria pollutants, these activity data were applied to the FAA's Aircraft Engine Emissions Database (AEED)- version 2.1. General aviation and air taxi emission estimates were calculated using FAA LTO data from *Air Traffic Activity - Fiscal Year 1996*, and EPA State Implementation Plan (SIP) guidance. All aircraft criteria estimates were speciated into individual Hazardous Air Pollutants (HAP) based on guidance provided by Office of Transportation and Air Quality (OTAQ).

Aircraft emissions were assigned to 600 FAA towered airports that submitted FAA Form 5010 Applications. Emissions were allocated to individual airports based on airport LTO data for each aircraft type (i.e., air carriers, general aviation, and air taxis).

CMV

The NTI includes two classifications of CMVs, diesel-powered vessels which account for 95% of the fleet and steam-powered vessels that burn residual fuels.

National CMV criteria emissions for 1996 were provided by OTAQ staff who were involved in the EPA's recent marine diesel engine rule making. Estimates for steam-powered vessels were calculated using Department of Energy (DOE) bunkered fuel data obtained from *Fuel Oil and Kerosene Sales, 1996* and emission factors from EPA SIP guidance. The criteria emission estimates were speciated into individual HAPs based on guidance provided by OTAQ. These national emission estimates were assigned to the top 150 ports, based on the amount of cargo handled as estimated in the U.S. Army Corps of Engineers' *Waterborne Commerce of the United States, Calendar Year 1996, Part 5- Waterways and Harbors National Summaries*.

Railroad

Railroad activities are divided into a number of operation based on type service provided and the size and scope of the operations. Class I railroads include the large railroad companies that move cargo within large regions or even across the country. Class II and III railroads tend to be smaller companies that provide service to smaller areas, such as a state or metropolitan area. Yard locomotives move railroad cars within the limited area of a railroad yard. Passenger service is primarily associated with Amtrak, though local commuter lines also provide passenger service, but to a much more limited geographic area.

The national locomotive criteria emission estimates were provided by OTAQ staff involved in the EPA's recent locomotive rule making. These criteria emission estimates were speciated into individual HAPs based on guidance provided by OTAQ. The national railroad emissions were spatially allocated to individual counties based on population data obtained from U.S. Department of Commerce's *Estimates of Population of Counties: Annual Time Series*.

Summary of Methods Used in the 1999 NEI

Aircraft

National aircraft specific LTO data for 1999 were obtained from the FAA's *Airport Activity Statistics of Certified Route Air Carriers, 12 Months Ending December 31, 1999*. National aircraft criteria emissions were estimated by applying the LTO data to version 4.0 of the FAA's Emissions Dispersion and Modeling System (EDMS), which contains a more complete database of aircraft than the older AEED. The 1999 emission estimates include foreign air carriers which were not included in the 1996 inventory. For general aviation and air taxis, LTO data were obtained from the FAA's *Air Traffic Activity - Fiscal Year 1999* and criteria emission were estimating used the same approach used in the 1996 inventory. The criteria estimates were speciated into individual HAPs based on guidance provided by OTAQ. Since the 1999 emission factors and activity data for air carriers were derived from more complete data sources than those used in the 1996 inventory, these two inventories should be considered of somewhat different quality. For general aviation and air taxis, the methods used in the two inventories were comparable.

Aircraft emissions were spatially assigned to over 2000 individual airports based on airport LTO data for each aircraft type (i.e., air carriers, general aviation, and air taxis). These airport GIS data were obtained from the Department of Transportation's *National Transportation Atlas Databases*. The airport data used for 1999 represents a significantly more complete inventory of airports than that used in the 1996 inventory, providing a more accurate spatial surrogate, especially with regard to many of the smaller municipal airports.

CMV

National CMVs criteria emissions for 1999 were obtained from the EPA's *Draft Regulatory Impact analysis: Control of Emissions from Compression Ignition Marine Engines* which was developed in support of recent marine diesel engine rule making. These studies provided estimates for 2000, but also included growth factors to allow for back calculation to 1999. Emission estimates from steam-powered vessels were calculated based on DOE bunkered fuel data obtained from *Fuel Oil and Kerosene Sales, 1999* and emission factors from the EPA's SIP guidance. These criteria emission estimates were speciated into individual HAPs based on guidance provided by OTAQ. Since the data sources and calculation methods used in the 1996 and 1999 inventories are similar, the emission estimates should be considered comparable.

The national emission estimates were disaggregated into port level emissions and underway emissions. The port estimates continued to be assigned to the top 150 ports, as was done in the 1996 inventory. While underway emissions were allocated to shipping lanes based on traffic volume data which was not considered when the 1996 inventory was being developed. The shipping lanes data used in the 1999 inventory were obtained from the Bureau of Transportation Statistics' *National Transportation Atlas Databases - National Waterway Network*.

Railroad

The national locomotive criteria emission estimates were calculated using national fuel data from the Association of American Railroads' *Railroad Facts* and emission factors obtained from the

EPA's *Emission Factors for Locomotives* which was developed in support of recent locomotive rule making. These criteria emission estimates were speciated into individual HAPs based on guidance provided by OTAQ. The methods used in the 1999 inventory are similar to those used in the 1996 inventory; therefore, these emission estimates should be considered comparable.

The national railroad emissions were allocated to the volume of rail traffic per track length as provided in the Bureau of Transportation Statistics' *National Transportation Atlas Databases - National Railway Network*. This approach represents a significant improvement over the 1996 approach of spatially allocating emissions based on Census Department population data.

Comparison of 1996 and 1999 inventories

The use of FAA's GIS data (see Figure 1) allowed for the inclusion of 1,400 smaller municipal airports. This provided a more accurate method of allocating general aviation and air taxi emission estimates. The approach used for the 1996 inventory to allocate commercial air carriers was similar to that used in the 1999 inventory. Figure 1 also shows counties which noted an increase or decrease in emissions between 1996 and 1999. Most of the counties that show increases are due to the inclusion of these smaller municipal airports. Counties that show decreased emissions are due to the improved spatial allocation of general aviation and air taxi emission estimates.

The largest effect of the new allocation methodologies for CMVs is limited to counties which have navigable waterways, but no commercial ports. In the approach used in the 1996 inventory, CMV emissions were only attributed to counties with commercial ports. Because the 1999 emission inventory method is able to account for underway emissions, all counties with shipping lanes (see Figure 2) now have emissions attributed them. Figure 2 also shows increases or decreases in emissions between 1996 and 1999. Emissions declined in individual ports due to the fact that underway emissions were removed from port emission estimates and more accurately assigned to shipping lanes. Some port emissions also declined in the 1999 inventory due to the inclusion of data developed by local authorities using local port data, such as the Houston/Galveston shipping channel.

The use of GIS rail data allowed for the reallocation of locomotive emissions from over 600 counties that had emissions erroneously assigned to them in the 1996 NTI. Figure 3 shows the location of Class I railroad tracks included in this inventory. Unfortunately activity data per track length could not be presented easily in a graphic format and therefore only track locations are noted in the figure. Figure 3 also notes increases or decreases in county level emissions. For the most part, emission increased in counties that had Class I railroads, this was particularly noticeable for counties that were sparsely populated in the 1996 census data. One significant problem that was encountered in this approach was that the states without Class I rail operations had no locomotive emissions attributed to them even though they may have considerable Class II/III, passenger, commuter, or yard operations. This is most noticeable in the northeast section of the country.

Proposed Future Improvements

Aircraft

For aircraft emission sources, future inventories can be improved significantly by continuing to incorporate state and local emission estimates into the NEI that have been developed based on accurate local airport activity data and use of the latest version of EDMS. This will be particularly helpful in quantifying emissions from general aviation and air taxis operating in smaller airports.

Currently, all aircraft-specific data must be entered into EDMS manually, which is why the 1999 emission estimates are calculated at the national level and allocated to individual airports base on LTO data. The next version of EDMS is planned to allow batch downloading of FAA aircraft-specific data, which will make direct estimation of airport-specific emissions possible.

Aircraft-specific LTO data on foreign air carriers are not readily available through the FAA. For the 1999 inventory, OTAQ provided total LTO data for foreign air carriers, which were applied to average commercial aircraft emission factors. In future version of this inventory, aircraft-specific data for foreign air carriers will be used.

Military aircraft emissions continue to be difficult to estimate both at the national and local levels. Currently, OTAQ and the Emission Factor and Inventory Group (EFIG) are reviewing plans to revise military aircraft methodologies.

CMV

CMV estimates can be significantly improved through the inclusion of local inventory studies that use the latest emission factors incorporated in the background documents for recent marine diesel rule making. For the 1999 inventory effort, local port data have been provided for relatively few ports such as Houston, Pittsburgh, and Philadelphia.

Railroad

One of the problems encountered in the 1999 inventory occurs because the GIS data set used to allocate emissions is derived from data submitted by Class I railroads. States without Class I rail operations show no railroad emissions in 1999 even though they may have class II/III, commuter rail, passenger rail and yard operations. In the next version of the 1999 inventory, the national locomotive emissions will be disaggregated into the following categories

- Class I
- Class II/III
- Passenger
- Commuter
- Yard

The data set currently used for Class I railroads will be used to allocate emissions only for Class I rail operations. Passenger train emissions are mostly from Amtrak operations and a GIS data set of Amtrak activity will be used to allocate these emission estimates. We have also identified a

GIS data set from the Bureau of Transportation Statistics - National Railway Network and the Federal Railroad Administration that quantifies the number and location of yard locomotives, which can be used to allocate emission estimates from this source. For Class II/III and commuter activities, specific GIS data for these operations are not readily available. Instead, county-level track length will be used to allocate emissions.

Conclusions

The use of GIS data allowed for spatial allocation of national level emission estimates to individual counties. For some source categories, such as Class I railroads, these GIS techniques are particularly useful. Though these GIS methods represent a significant improvement in how emissions for these source categories can be spatially allocated, these techniques do not diminish the need for emission estimates developed using local activity data and the latest emission factors or models, particularly with regard to port emissions for CMVs and aircraft emissions from some of the smaller airports.

References

U.S. EPA/EFIG Documentation for the Draft 1999 Base Year Aircraft, Commercial Marine Vessel, and Locomotive National Emission Inventory for Criteria and Hazardous Air Pollutants, October 29, 2001.

U.S. EPA/EFIG Documentation for the 1996 Base Year National Toxic Inventory for Commercial Marine Vessel and Locomotive Mobile Sources, September 30, 1999.

U.S. EPA/EFIG Documentation for the 1996 Base National Toxic Inventory for Aircraft Sources, November 4, 1998.

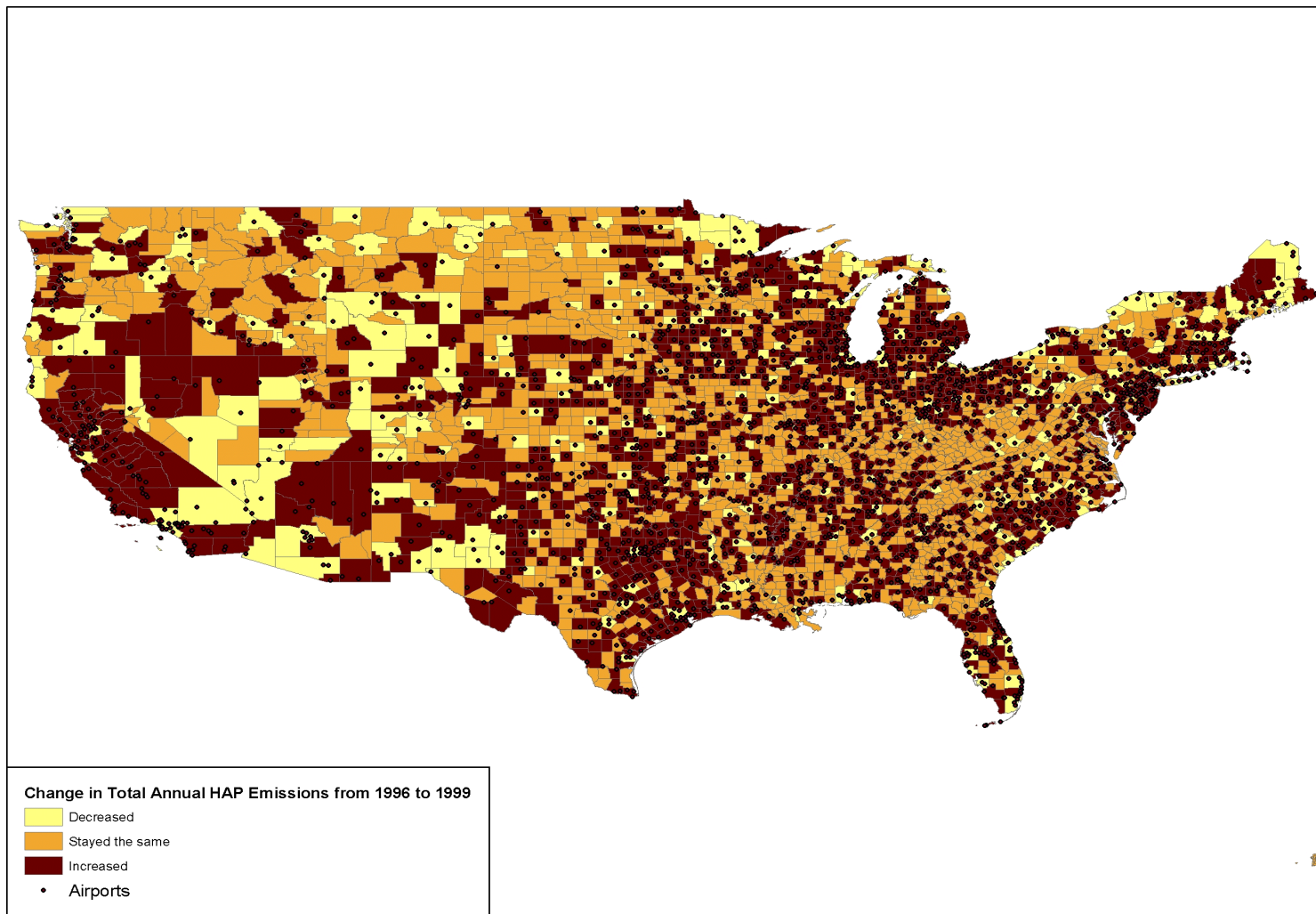


Figure 1. Comparison of 1996 and 1999 Spatial Allocation Methods for Aircraft

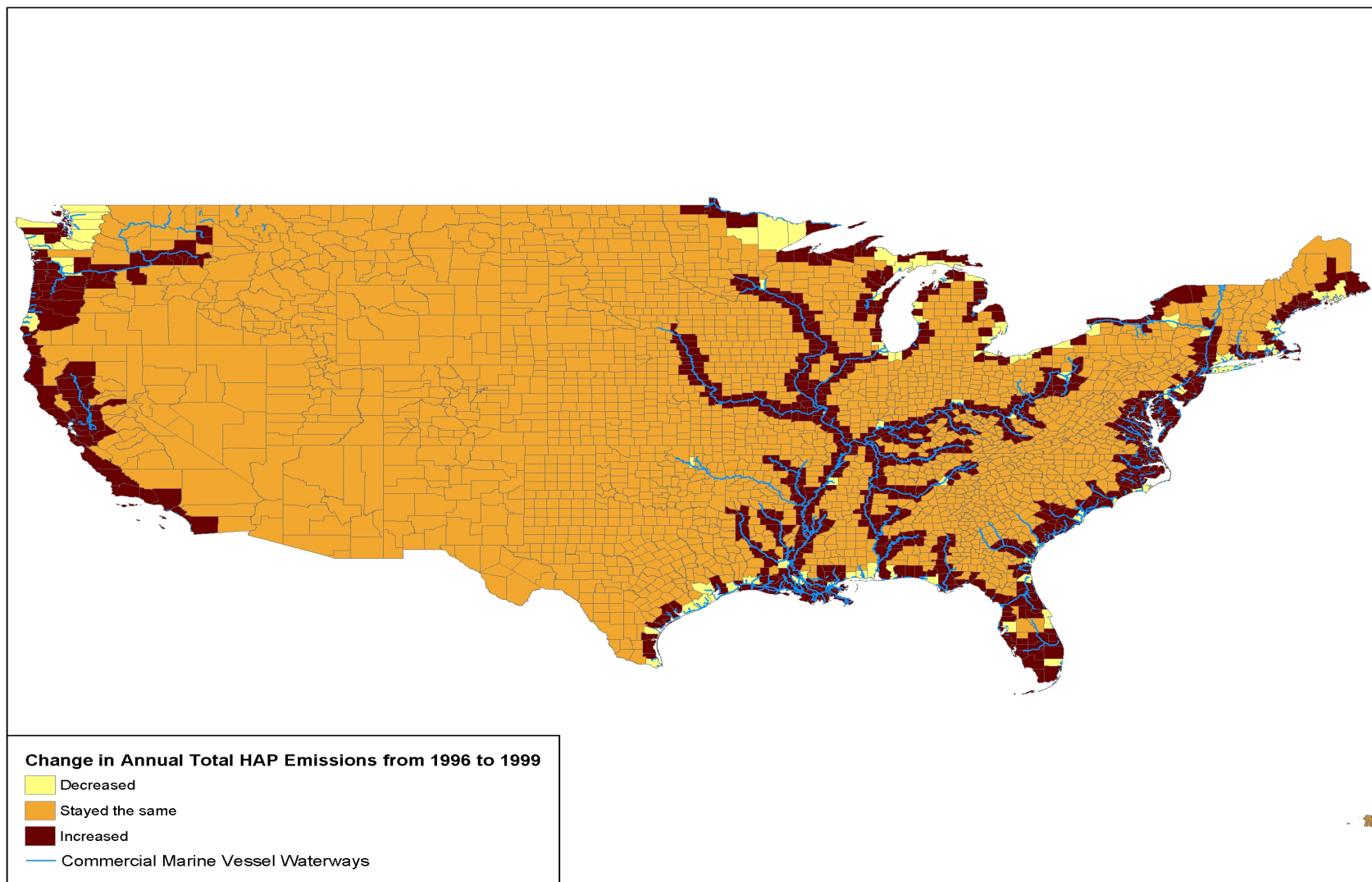


Figure 2. Comparison of 1996 and 1999 Spatial Allocation Methods for Commercial Marine Vessels

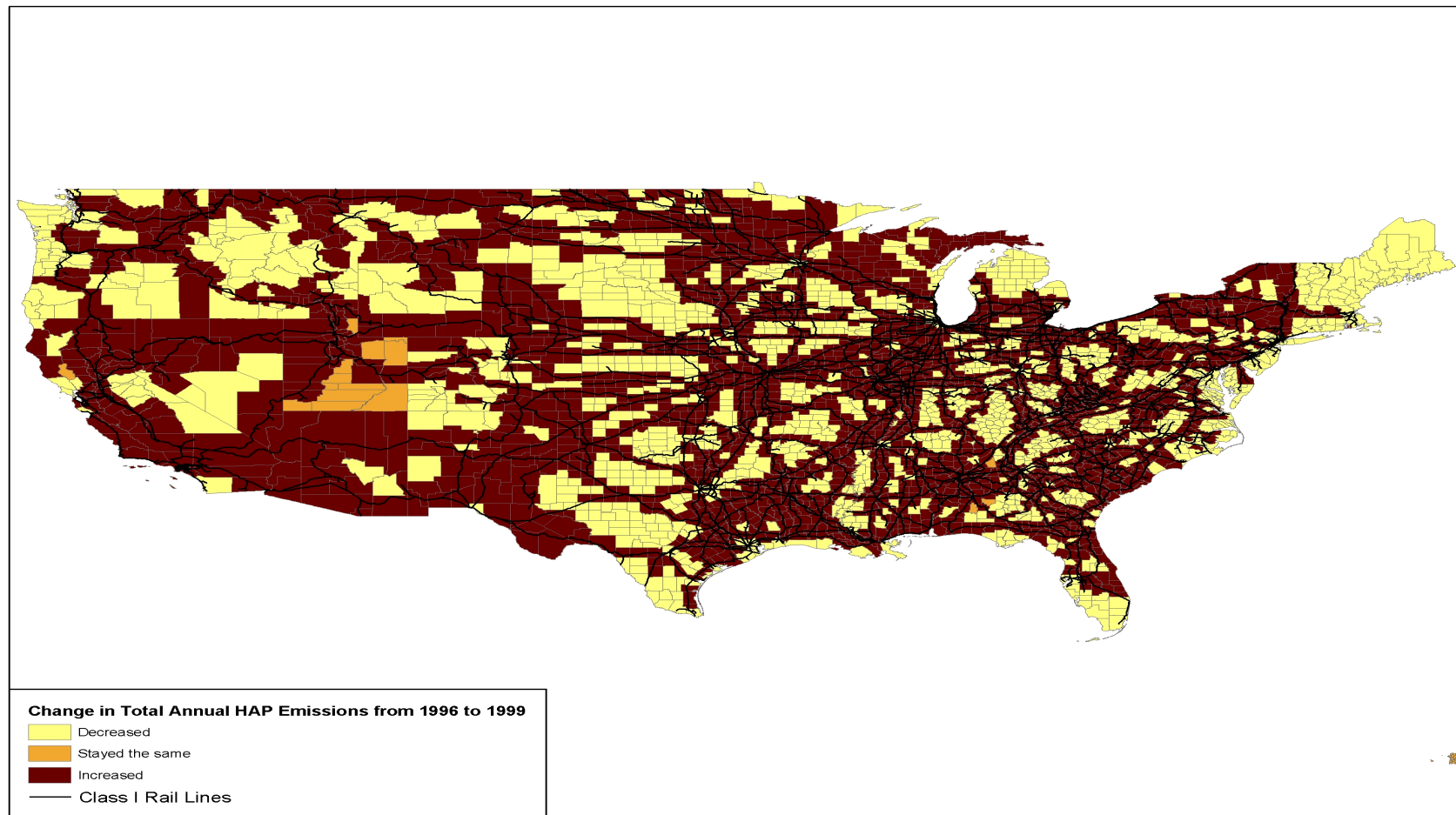


Figure 3. Comparison of 1996 and 1999 Spatial Allocation Methods for Railroads